LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA6 | South Ruislip to Ickenham

Water resources assessment (WR-002-006)

Water resources

November 2013

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Two specific appendices for each community forum area (CFA) are also provided. For the South Ruislip to Ickenham CFA (CFA6) these are:

- a water resources assessment (i.e. this appendix); and
- a flood risk assessment (Volume 5: Appendix WR-003-006).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Study area

1.2.1 The South Ruislip to Ickenham CFA extends from the boundary with the Northolt Corridor CFA (CFA5) directly south of Rabournmead Drive, South Ruislip. The Proposed Scheme will then proceed to the north-west in tunnel for 4.4km. A tunnel portal will be constructed in West Ruislip, approximately 70m west of Ickenham Road. After gradually returning to the surface on a ramp within the portal structure, the route will be on embankment with bridges across the River Pinn and Breakspear Road South.

1.2.2 The spatial scope of the assessment was based upon the identification of surface water and groundwater features within 1km of the centre line of the route, except where there is clearly no hydraulic connectivity. For surface water features in urban areas, the extent was reduced to 500m. Outside of these distances it is unlikely that direct impacts upon the water environment will be attributable to the Proposed Scheme. Where works extend more than 200m from the centre line, for example at stations and depots, professional judgement has been used in selecting the appropriate limit to the extension in spatial scope required. For the purposes of this assessment this spatial scope is defined as the study area.

1.2.3 The main environmental features of relevance to water resources include:

- water features including the Yeading Brook (East and West arms), the River Pinn, Newyears Green Bourne, which are all main rivers and the Ickenham Stream, which is a main river south of the existing Chiltern Main Line (originally constructed as a feeder for the GUC and referred to elsewhere as the 'canal feeder');
- the Chalk Principal aquifer and the Lambeth Group and Thanet Sand Secondary A aquifer; and
- one licensed groundwater abstraction for public water supply (PWS) which has

an associated source protection zone (SPZ) within 1km of the route, which abstracts water from the Chalk aquifer. The route will pass through SPZ1.

1.2.4 Key environmental issues relating to water resources include:

- channel diversions on the Ickenham Stream and the Newyears Green Bourne;
- the potential impact to groundwater flows as a result of the construction of the tunnel and associated underground structures;
- the potential for impacting groundwater quality in the Chalk Principal aquifer as a result of construction activities associated with underground structures such as tunnelling, piling and retaining walls; and
- the route will pass through SPZ1 and thus there is the potential for an impact on the abstraction used for PWS.

1.2.5 Where there is a residual impact to water resources and following mitigation there is a consequent effect on ecology, this is discussed further in Volume 2, South Ruislip to Ickenham (CFA report 6), Section 7.

2 Stakeholder engagement

2.1.1 Discussions have been held with the following stakeholders to inform the water resources assessment:

- the Environment Agency to discuss the Harvil Road Bridge and River Pinn bridge design. Meetings have primarily focussed on the flood risk aspects of the design but included discussion of the requirements for channel realignments and possible length of culverts ;
- Affinity Water regarding their groundwater source in this study area;
- a private licensee by informing them through a questionnaire and requesting further information or a meeting to more accurately assess and understand any potential risks to private abstractions; and
- the Canal & River Trust (formerly British Waterways) regarding the Ickenham Stream and the water supply to the Grand Union Canal (GUC).

3 Baseline data

3.1 General

3.1.1 The following sub-sections provide a current description of water resources within the study area including surface water and groundwater features.

3.1.2 All water bodies in this area fall within the Colne catchment of the Thames River Basin District as defined under the Water Framework Directive[1] (WFD) and are covered by the River Basin Management Plan[2] (RBMP).

3.2 Surface water

3.2.1 All surface water features within 1km of the route[3] are presented in Table 1.

3.2.2 The current surface water baseline and water features with codes listed in Table 1 are shown in Map WR-01-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The map reference is in one of two forms. If the feature has a specific reference number then this is provided (e.g. a surface water crossing will be referenced as SWC-CFA06-01). If the feature has no specific reference its location on a specific map is provided (e.g. WR-01-007, D6) where D6 is a grid reference using the map specific grid.

3.2.3 The surface water features are based on the Environment Agency's Detailed River Network (DRN) with the addition of water bodies noted on the Ordnance Survey's (OS) 'OS VectorMapDistrict'.

[1] European Parliament and European Council (2000). Water Framework Directive - Directive 200/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.
[2] Environment Agency (2009). River Basin Management Plan, Thames River Basin District.
[3] The Environment Agency's Detailed River Network (DRN) shows the route to cross a culverted watercourse (Map WR-01-002). The watercourse has been included in the DRN to ensure connectivity. It is considered that any such watercourse is a part of the sewer network and is not a surface water feature. It has therefore not been included in this assessment.

Table 1: Surface water features within 1km of the route in CFA6.

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
One small pond - Lord Halsbury Memorial Playing Fields	Within Lord Halsbury Memorial Playing Fields south of the route but will be within the land potentially required for construction. (CFA06-P01)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	No surface water linkage with Yeading Brook (East Arm) or other surface water features.
Yeading Brook (East Arm)	Will be intersected by the route near Field End, South Ruislip. (SWC-CFA6-01)	Main river	Yeading Brook (East Arm) GB106039023060 Moderate	Good Potential	High	0.005	6.08	The brook is diverted around the A40/A4180 interchange before entering Yeading Brook 1.1km west of the interchange and south of the A40.
Two drains and one small pond at Ruslip Manor	Recreation ground at Ruislip Manor. (CFA06-P02)	Ordinary watercourse	No status class shown in RBMP – assumed status Moderate	No status class shown in RBMP – assumed status Good Potential	Moderate	Not applicable	Not applicable	The pond is connected to the drains which flow into Yeading Brook (West Arm).

[4] Water-feature classifications: Section 113 of the Water Resources Act 1991 defines a main river as a watercourse that is shown as such on a main river map. Section 72 of the Land Drainage Act 1991 defines an ordinary watercourse as 'a watercourse that is not part of a main river'. Section 221 of the Water Resources Act 1991 defines a watercourse as including 'all rivers and streams, ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers) and passages through which water flows'. Main rivers are larger rivers and streams designated by the Department for Environment, Food and Rural Affairs (Defra) on the main river map and are regulated by the Environment Agency

[5] For examples of receptor value, see Table 43 in the Scope and Methodology Report (SMR) Addendum, Volume 5: Appendix CT-001-000/2.

[6] Q95 is the flow which is exceeded for 95% of the time (i.e. it is a low flow and the river will only have flows less than this for 5% of the time).

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
Yeading Brook (West Arm)	Will be intersected by the route near Bedford Road, Ruislip Gardens. (SWC-CFA6-04 and 05)	Main river	Yeading Brook (West Arm) GB106039023060 Moderate	Good Potential	High	0.006	13.32	The brook flows to the south-west of the route and is culverted under the A40 approximately 2.1km from the route. Ultimately it joins the River Crane east of Hayes Town.
Several small ponds and drain - Ruislip Gardens	Within recreation grounds of Ruislip Gardens south of the route. (CFA06-P03)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are isolated and not connected to other surface water features. The drain flows towards Yeading Brook.
Pond and drains at Ruslip Golf Course	Ruslip Golf Course. (SWC-CFA6-06) (CFA06-P05)	Not applicable	No status class shown in RBMP – assumed status Moderate	No status class shown in RBMP – assumed status Good Potential	Moderate	Not applicable	Not applicable	The pond discharges into one of the drains feeding into the Ickenham Stream that is crossed at SWC-CFA6-07.
Ickenham Stream and tributary	Ruislip Golf Course. (SWC-CFA6-03 and 07)	Ordinary watercourse	No status class shown in RBMP – assumed status Moderate	No status class shown in RBMP – assumed status Good Potential	Moderate	Not applicable	Not applicable	The Ickenham Stream was constructed as a feeder to the GUC. It flows from what is now called Ruislip Lido. The stream alignment crosses the River Pinn at the northern boundary of Ruislip Golf Course. Flows from the north and track drainage from the existing railway have been diverted into a complex system draining northwards back to the River Pinn. Flows south of the existing railway pass into the Yeading Brook (West Arm).

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
River Pinn	West of Ruislip Golf Course. Will be crossed by the route near Gatemead Farm. (SWC-CFA6-02)	Main river	Pinn GB106039023070 Moderate	Good Potential	High	0.009	38.78	The River Pinn flows southwards from the route, crosses the GUC at Philpots Bridge and enters the River Colne at West Drayton.
Three small ponds and a moat	Brackenbury Farm. (CFA06-P04)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds and moat do not appear to be connected to any other surface water features.
Small drain and pond	South-east of Newyears Green Covert and north of Brackenbury Farm. (SWC-CFA6-08 and 09)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Small isolated drain and pond. Not connected to other surface watercourses.
Pond at Newyears Green	Located off Newyears Green Lane in Newyears Green. (CFA06-P06)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated pond.
Several small drains and pond – Newyears Green	Around Newyears Green, will be to the north of the route in area required for sustainable placement of materials. (CFA06-P06)	Ordinary watercourse	No status class shown in RBMP – assumed status Poor	No status class shown in RBMP – assumed status Good Potential	Moderate	Not applicable	Not applicable	The drains are connected to the Newyears Green Bourne, the ponds are small, isolated, overgrown ponds in fields apart from one larger pond which appears to be used for drainage or as a large commercial composting site.

Water feature	**Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)**	**Watercourse classification[4]**	**WFD water body and current overall status**	**WFD status objective (by 2027 as in RBMP)**	**Receptor value[5]**	**Q95[6] (m^3/s)**	**Catchment area at crossing (km^2)**	**Notes**
Newyears Green Bourne	North-west of Newyears Green Covert. Will be crossed by the realigned Harvil Road that will be approximately 150m north of the route at the boundary with CFA7. (SWC-CFA6-10)	Main river	No status class shown in RBMP – assumed status Poor	No status class shown in RBMP – assumed status Good Potential	Moderate	0,012	5.17	The Newyears Green Bourne flows towards the River Colne through a culvert under Harvil Road and a new crossing will be constructed.

3.2.4 There are no surface water abstractions identified within 1km of the route in the study area[7]. There is the potential for unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

3.2.5 Table 2 summarises groundwater discharge consents to groundwater, directly or via land, within 1km of the route.

Table 2: Summarises surface water discharge consents within 1km of the route

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving water body
CFA6-WD34	Temp.2208	185m (north)	Sewage discharge - pumping station - water company	Ickenham Stream
CFA6-WD35	Temp.2118	835m (north-east)	Sewage discharge - pumping station - water company	Smart Brook (tributary of Yeading Brook)
CFA6-WD16	CNTM.2277	760m (south-west)	Discharge of other matter - surface water	Yeading Brook (west)
CFA6-WD17	CNTM.2278	805m (south-west)	Discharge of other matter - surface water	Yeading Brook (west)
CFA6-WD6	CNTM.2279	620m (south-west)	Discharge of other matter - surface water	Yeading Brook (west)
CFA6-WD21	CNTM.2276	585m (south-west)	Discharge of other matter - surface water	Yeading Brook (west)
CFA6-WD7	CNTM.2280	575m (south-west)	Trade effluent discharge -site drainage	Yeading Brook (west)
CFA6-WD15	CNTM.2275	485m (south-west)	Trade effluent discharge -site drainage	Yeading Brook (west)
CFA6-WD14	CNTM.2274	345m (south-west)	Trade effluent discharge -site drainage	Yeading Brook (west)
CFA6-WD12	CNTM.2272	295m (south-west)	Trade effluent discharge -site drainage	Yeading Brook (west)
CFA6-WD13	CNTM.2273	255m (south-west)	Trade effluent discharge -site drainage	Yeading Brook (west)
CFA6-WD11	CNTM.2270	220m (south-west)	Trade effluent discharge -site drainage	Yeading Brook (west)
CFA6-WD10	CNTM.2285	165m (south-west)	Discharge of other matter - surface water	Yeading Brook (east)
CFA6-WD9	CNTM.2284	170m (south-west)	Discharge of other matter - surface water	Yeading Brook (east)
CFA6-WD20	CNTM.2271	170m (south-west)	Discharge of other matter - surface water	Yeading Brook (east)

[7] Surface water abstractions for public supply are not included.

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving water body
CFA6-WD19	CNTM.2282	175m (south-west)	Discharge of other matter - surface water	Yeading Brook (east)
CFA6-WD18	CNTM.2281	180m (south-west)	Discharge of other matter - surface water	Yeading Brook (west)
CFA6-WD28	Canm.0721	180m (south-west)	Trade effluent discharge - site drainage	Yeading Brook (east)
CFA6-WD32	Temp.2592	735m (north-east)	Public sewage: storm sewage overflow	Yeading Brook (east)
CFA6-WD33	Temp.0347	om	Sewage discharges - pumping station - water company	Yeading Brook (east)

3.3 Groundwater

3.3.1 A summary of the geological units present in in the study area, along with their hydrogeological characteristics, is presented in Volume 2, CFA Report 6, Section 13.3.

3.3.2 Map WR-02-006 (Volume 5, Water Resources and Flood Risk Assessment Map Book) illustrates the spatial distribution of the uppermost superficial and bedrock formations within CFA06.

3.3.3 A schematic cross-section along the line of the route in this study area with regard to geological strata, groundwater elevations (average, where known) and the Proposed Scheme is presented in Figure 1.

3.3.4 A cover of made ground may be present along the route where it is at the surface, due to the presence of an existing rail corridor (comprising track-bed materials and existing embankments) as well as from previous cycles of development along the edge of the existing railway.

3.3.5 Superficial deposits are present at the western end of this section of the Proposed Scheme and comprise a narrow ribbon of alluvium associated with the River Pinn.

3.3.6 The bedrock geology comprises an outcrop of the Lambeth Group present to the north of the route at Ruislip Gardens Station and also approximately 200m either side of the River Pinn. In this area it is described as mottled sandy clay and clayey sand. The bedrock geology under the remainder of the study area is the London Clay Formation. This is underlain by the Lambeth Group which is itself directly underlain by the Cretaceous Chalk Group in this area.

3.3.7 Groundwater elevation data for the Chalk aquifer indicates the groundwater is under pressure or 'confined' beneath the overlying formations. Groundwater flow within the Chalk is generally towards the east and south-east in response to groundwater levels that decline from the north-west to the south-east.

3.3.8 These groundwater levels indicate that the Proposed Scheme (tunnel) is below the Chalk groundwater table for the majority of the route from the CFA5/6 boundary to

the Ruislip tunnel west portal. Towards the Ruislip tunnel west portal the elevation of the route rises to the surface and above the maximum recorded groundwater levels. This interchange between the parts of the route below and above the water table is unlikely to be significantly different during periods of minimum groundwater levels. Contours of groundwater elevations in the Chalk aquifer are shown in Figure 2.

3.3.9 Water level hydrographs for the Chalk aquifer from the Environment Agency's nearest points in the monitoring network are shown in Figure 3 and Figure 4.

3.3.10 The depth of the boundary between the Lambeth Group and the Chalk aquifer is currently not known precisely along much of the Proposed Scheme in this study area, so the cross-section in Figure 1 is considered indicative only.

Figure 1: Schematic geological cross-section for CFA6

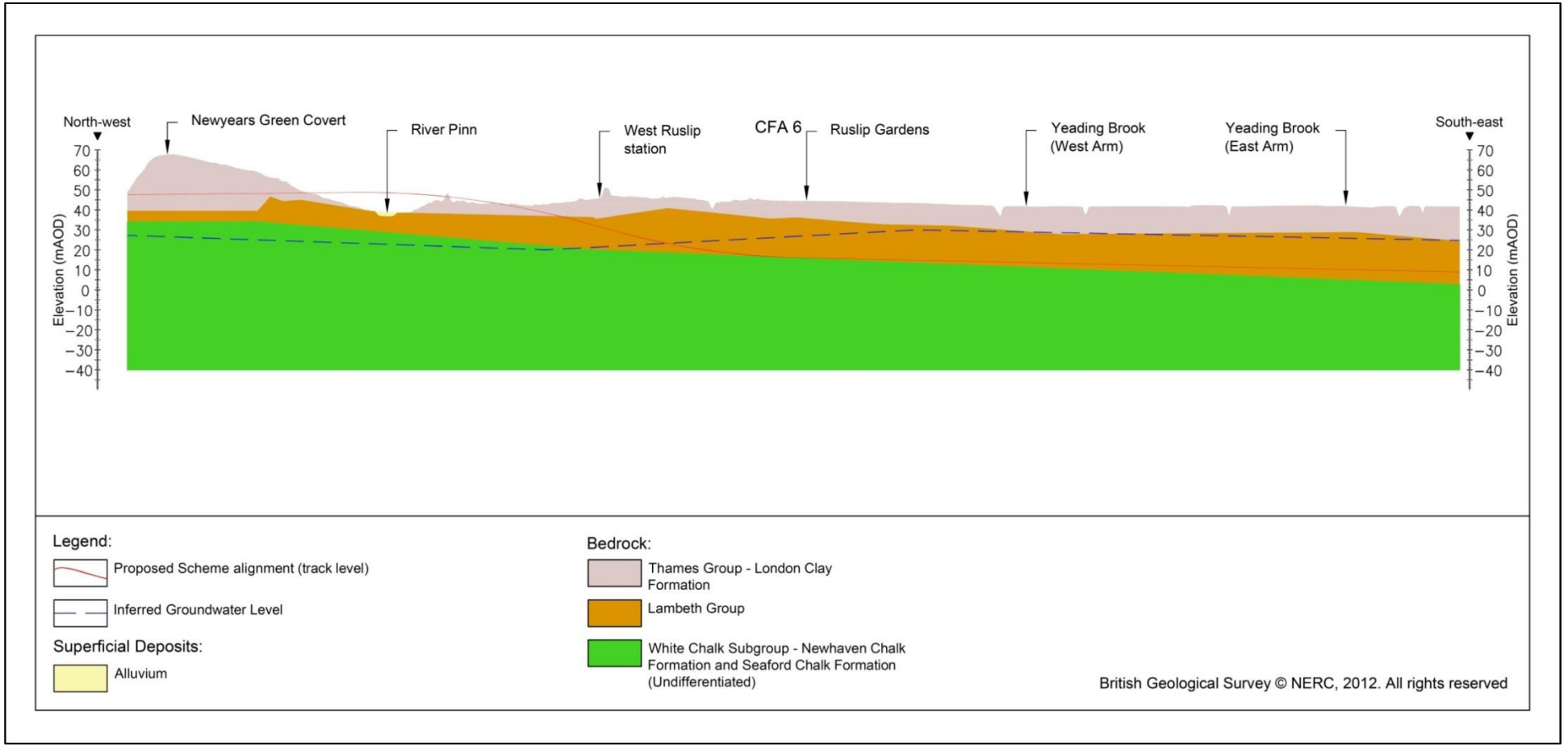


Figure 2: Groundwater level contours for London (including area of CFA6) as at January 2013.

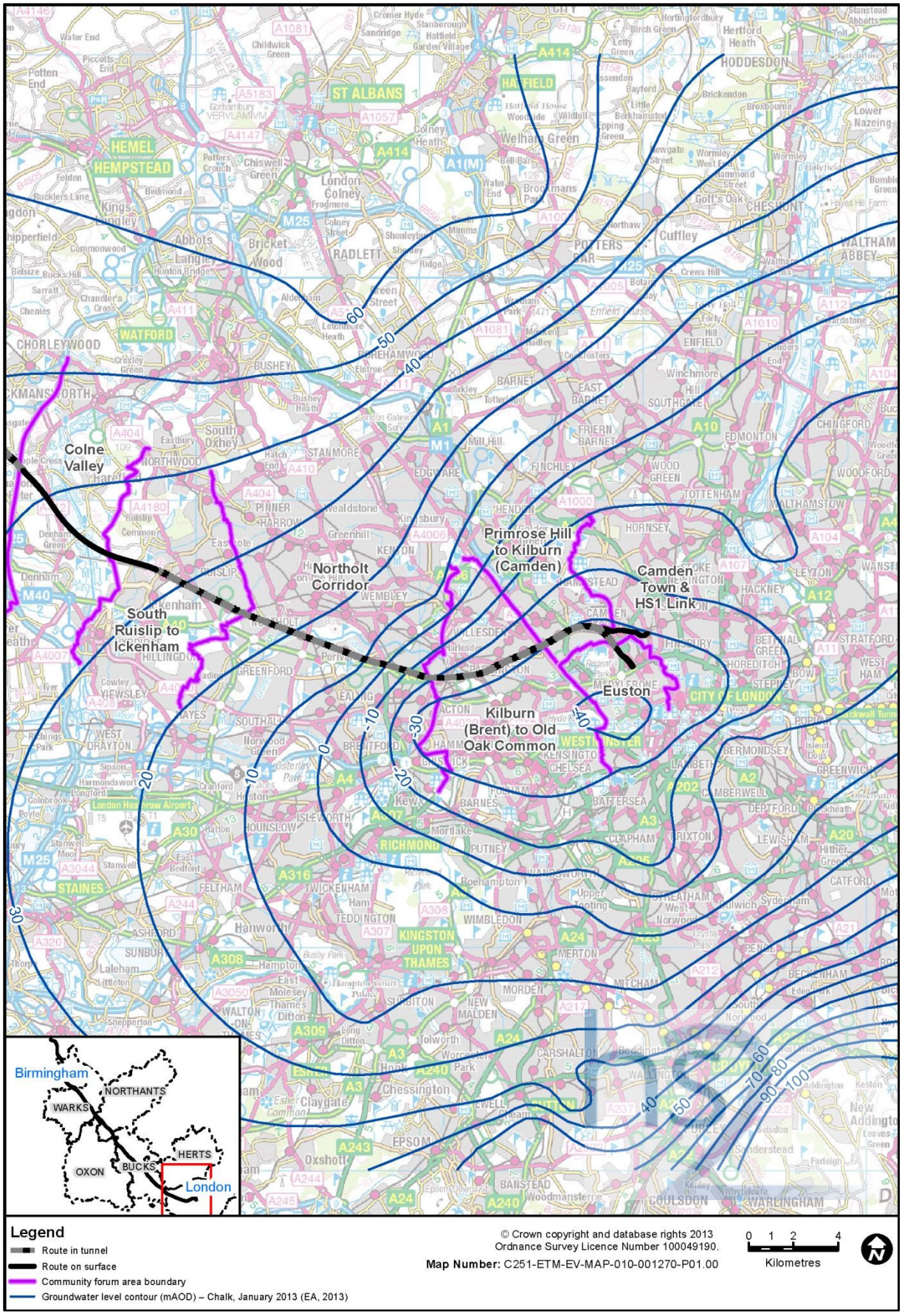


Figure 3: Groundwater level hydrograph for Borehole TQ18/35 - IBM Greenford (CFA5).

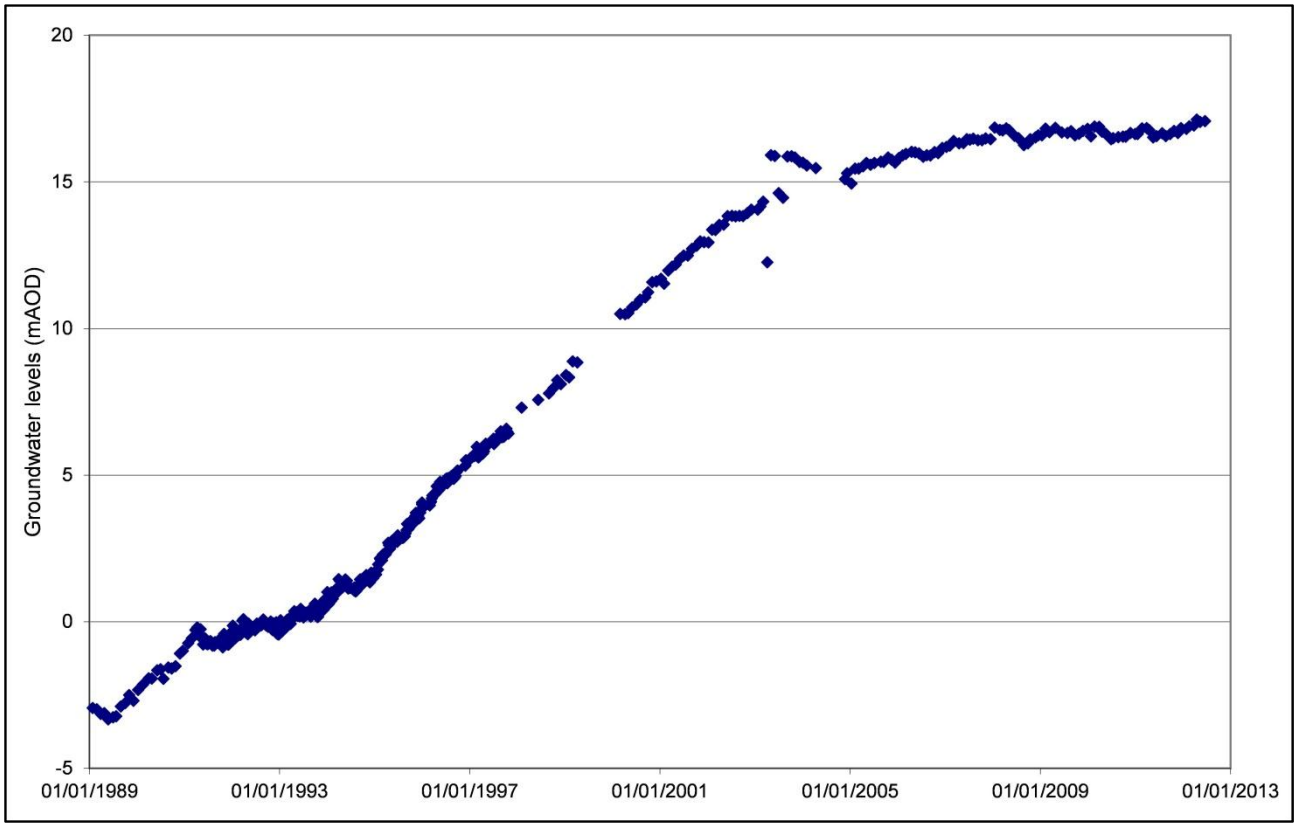
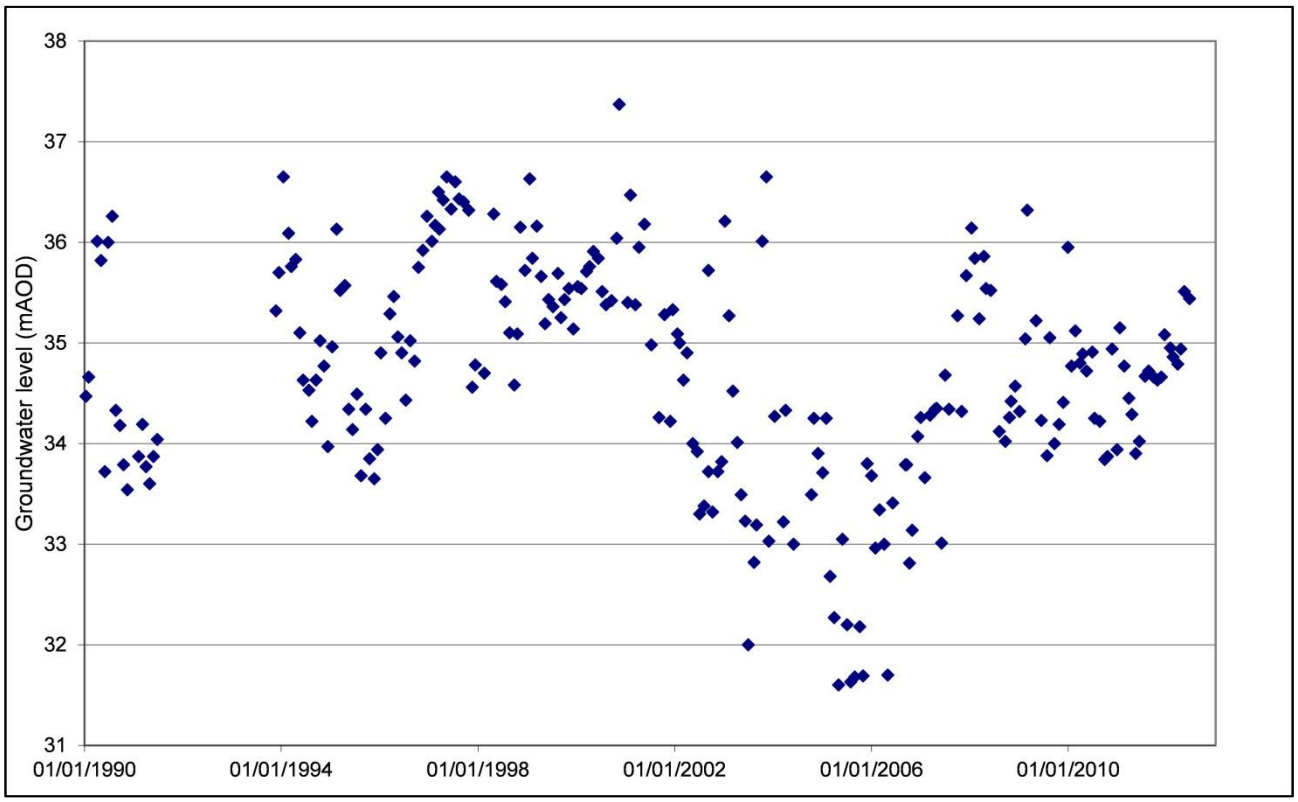


Figure 4: Groundwater level hydrograph for Borehole TQ08/9B – Denham Studios (CFA7) in the Colne Valley.



3.3.11 Table 3 summarises unlicensed and licensed groundwater abstractions (including PWS abstractions) or SPZ located within 1km of the route in the study area. There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

Table 3: Groundwater abstractions in this study area.

Licence identifier (map reference number and Environment Agency reference)	Distance and direction from route (m)	Abstraction horizon	Maximum annual abstraction quantity (m^3)	Maximum daily abstraction quantity (m^3/d)	Purpose	Number of boreholes
PWS (the reference number identifies the relevant SPZ1[8] on the maps)						
TH174 (licence identifier confidential)	285m (north)	Chalk	32,120,000 (covers group of abstractions)	12,502	PWS	Three
Private licensed water supplies						
GW46 (TH/039/0036/006)	965m (south)	Chalk	5700	88	Private, unknown	One
GW47 (TH/039/0036/006)	965m (south)	Chalk	3500	19	Private, unknown	One
Private unlicensed water supplies						
No data held by local authority						

3.3.12 No groundwater discharge consents within 1km of the route have been identified.

Surface water/groundwater interaction

3.3.13 Table 4 summarises the groundwater/surface water interactions within 1km of the route. Refer to Map WR-01-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book) for location of lakes and other surface water features.

[8] SPZ1 is defined as the 50 day travel time from any point below the water table to the source. This zone has a minimum radius of 50m. SPZ 2 is defined by a 400 day travel time from a point below the water table with a minimum radius of 250m or 500m around the source, depending on the size of the abstraction and SPZ3 is defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source. In confined aquifers, the source catchment may be displaced some distance from the source. For heavily exploited aquifers, the final Source Catchment Protection Zone can be defined as the whole aquifer recharge area where the ratio of groundwater abstraction to aquifer recharge (average recharge multiplied by outcrop area) is >0.75. There is still the need to define individual source protection areas to assist operators in catchment management. Environment Agency (2013). Groundwater protection: Principles and practice (GP3). August 2013, version 1.1.

Table 4: Groundwater/surface water interaction.

Location description	Distance and direction from route (m)	Formation	Approximate elevation (metres above Ordnance Datum, m AOD)	Comments
River Pinn	Crossed by route (SWC-CFA6-02)	Superficial/Alluvium	40m AOD	There is likely to be shallow groundwater present within the alluvium which is hydraulically connected to surface water in the vicinity of the River Pinn.

Water dependent habitats

3.3.14 The route will not cross any areas with statutory ecological designations in relation to surface water or groundwater.

4 Site specific surface water assessment

4.1 Summary of assessment

4.1.1 Table 5 summarises the potential impacts and effects to surface water features from the Proposed Scheme in the South Ruislip to Ickenham area. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 6, Section 13.4.

4.1.2 Table 5 only includes water features which could potentially be impacted by the Proposed Scheme. Features such as isolated ponds and drains which will lie outside the construction footprint and area of impact of the Proposed Scheme are not included. Details of these features are, however, provided in Table 1. Map references refer to those presented on Map WR-01-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

4.1.3 The draft Code of Construction Practice (CoCP) referred to in Table 5 sets out the measures and standards of work that will be applied to the construction of the Proposed Scheme (see Volume 5: Appendix CT-003-000/1). These will provide effective management and control of the impacts during the construction period.

4.1.4 Surface water crossing identification points are presented in Map WR-01-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

Table 5: Summary of potential impacts to surface water.

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Ickenham Stream	Moderate	Cutting for surface railway and diversion of Ickenham Stream Ickenham Stream will be severed and diverted into a new channel to the north of the route to flow into the River Pinn. (SWC-CFA06-03)	Potential surface water flow and quality effects due to sediment or spills. See Section 4.2 of this report for further discussion.	Moderate impact Moderate effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills. Suitable mitigation will be detailed within a site specific method statement as required by the draft CoCP and agreed with the Environment Agency. It will include details of the construction sequencing. The diversion channel will be pre-constructed prior to diversion. Flow control measures will be required around the location where the Ickenham stream is to be diverted. This will then allow water from the stream to be pumped into the diversion channel during the period when the diversion works are being completed to minimise the risk of contaminating the stream with sediment.	Minor impact Slight effect (Not significant)	None required	Minor impact Slight effect (Not significant)	Construction (temporary)
Ickenham Stream	Moderate	Cutting for surface railway and diversion of Ickenham Stream Ickenham	Possible loss of flow to the Ickenham Stream south of the proposed diversion.	Minor impact Slight effect (Not significant)	The detailed design of the realignments will be completed in consultation with the Environment Agency to seek to meet their objectives with respect to hydraulic capacity, flood risk, ecology and	Minor impact Slight effect (Not significant)	None required	Minor impact Slight effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
		Stream will be severed and diverted into a new channel to the north of the route to flow into the River Pinn. (SWC-CFA06-03)	See Section 4.2 of this report for further discussion.		hydromorphology.				
River Pinn	High	Crossing (SWC-CFA6-02)	Potential surface water flow and quality effects due to sediment or spills.	Negligible impact Neutral effect (Not significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Newyears Green ponds and field drain	Low	Sustainable placement	Coverage of four small ponds that are isolated from other surface water features and 100m of a field drain	Moderate impact Slight effect (Not significant on water resources)	None practicable as these small ponds will be covered over by materials from the Proposed Scheme. The drain will be covered over but runoff from the sustainable placement will still enter the remaining length of drain so no impact on hydrology likely. The draft CoCP and best practice will protect against potential pollution during construction. These ponds will be replaced with ecological	Moderate impact Slight effect (Not significant)	None required	Moderate impact Slight effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
					mitigation ponds.				
Newyears Green Bourne	Moderate	Stream diversion and new Harvil Road crossing (SWC-CFA6-10)	Potential surface water flow and quality effects due to sediment or spills. See Section 4.2 of this report for further discussion.	Moderate impact Moderate effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills. Suitable mitigation will be detailed within a site specific method statement as required by the draft CoCP and agreed with the Environment Agency. It will include details of the construction sequencing. The diversion channel will be pre-constructed prior to diversion to minimise the risk of mobilising sediment. Mitigation will be integrated with that undertaken for the viaduct crossing in the adjacent study area.	Minor impact Slight effect (Not significant)	None	Minor impact Slight effect (Not significant)	Construction (temporary)
Newyears Green Bourne	Moderate	Stream diversion and new Harvil Road Crossing (SWC-CFA6-10)	Realignment will introduce a more natural channel See section 4.2 of this report for further discussion.	Minor impact Slight effect (Not significant)	The detailed design of all watercourse realignments and crossings will be completed in consultation with the Environment Agency to meet their objectives with respect to hydraulic capacity, flood risk, ecology and hydromorphology. Where culverts are required these will be kept as short as possible. Further details in Volume 2, CFA6 Report, Section 13.	Beneficial effect (refer to Section 4.2 of this report for details)	None required	Beneficial effect (refer to Section 4.2 of this report for details)	Construction (permanent)

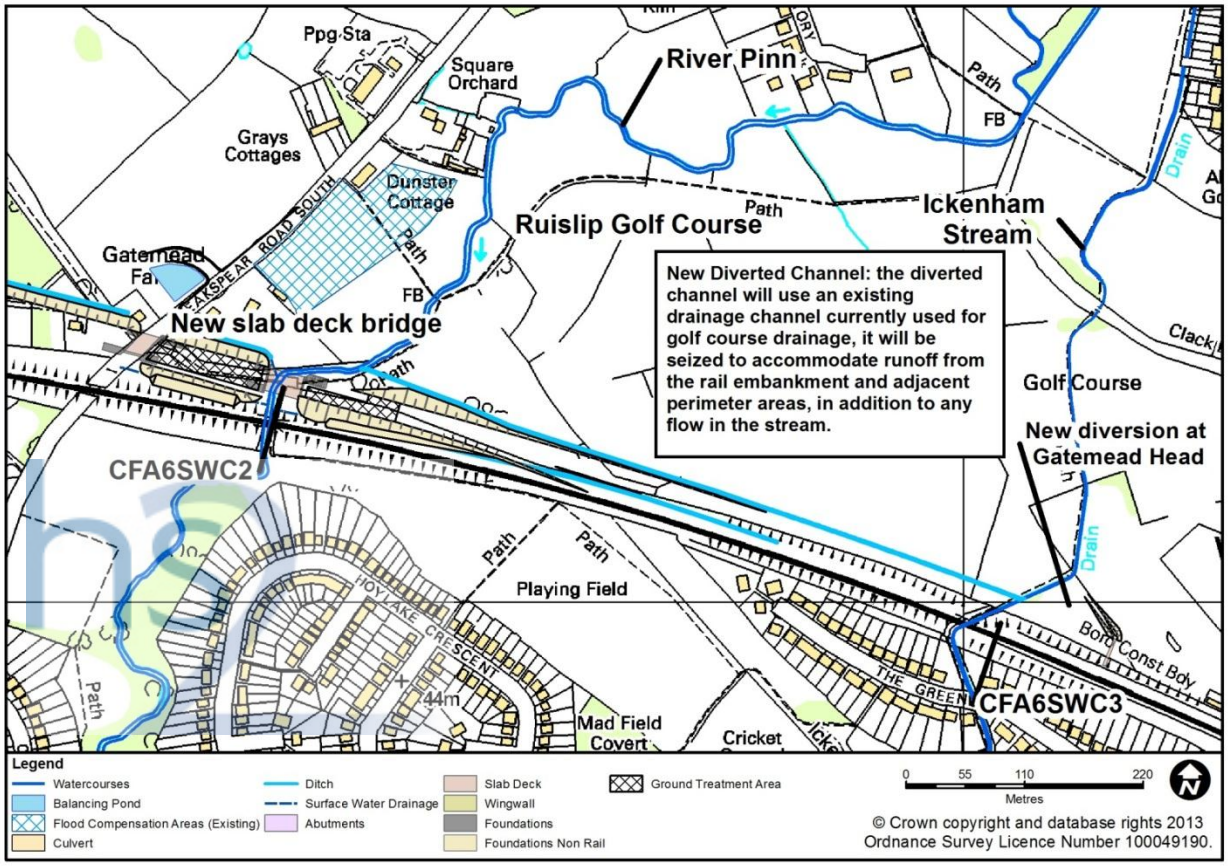
4.2 Detailed assessments

Assessment of diversions and culverts

4.2.1 The crossing arrangements have been the subject of extensive discussions with the design team and with the Environment Agency in an effort to incorporate measures in to the design to minimise potential impacts and address WFD issues. With the incorporated mitigation measures supported by pre- and post-construction monitoring and adherence to the requirements of the draft CoCP, significant effects have been avoided.

4.2.2 The Ickenham Stream (considered to be a receptor of moderate value) will be diverted at Gatemead Head (18m north of the route) westwards to the River Pinn (Map WR-01-07 SWC-CFA6-03) (see Figure 5). The stream was originally constructed as a feeder for the GUC and enters Yeading Brook (West Arm) at North Hillingdon. It is not given a WFD classification. The Yeading Brook (West Arm) is a heavily modified waterbody and has been classified as being at 'poor potential' by the Environment Agency (due to biological elements). The flow in the stream is controlled at the outlet to Ruislip Lido and passes through several culverts before joining the Yeading Brook (West Arm). Most notably it has been realigned and culverted under the A40 and A347 at Freezeland Covert.

Figure 5: Ickenham Stream diversion.



4.2.3 Existing modifications to the stream, including regrading and diversion to Ruislip Golf Course, already result in the majority of the base flow for the feeder discharging into the River Pinn catchment. Consequently, there will be a negligible change in the local contributing catchments.

4.2.4 The Ickenham stream diversion in the Ruislip Golf Course will be sized to accommodate run-off from the rail embankment and adjacent perimeter areas along the north side of the Proposed Scheme, in addition to any flows in the stream. In some sections of the diversion, where current ground levels rise well above the level of the watercourses, the stream may need to be conveyed in a pipe.

4.2.5 It is therefore considered that the magnitude of the impact of the proposed diversion on surface water flows will be negligible and the significance of the effects will be neutral.

4.2.6 There is a likelihood, however, of in-channel works being required to facilitate the diversion, which will cause a potential impact on water quality. This will be mitigated through application measures in the draft CoCP and appropriate planning for bringing the stream into use. As a result it is considered there could be a minor impact during construction, leading to a slight, short term effect on sediment transport.

4.2.7 The Newyears Green Bourne (a moderate value receptor) passes under the existing alignment of Harvil Road via a culvert which is known to be a constraint to high flows currently leading to flooding of the road. The river will be diverted to pass under the new Harvil Road embankment via a culvert crossing (Map WR-01-007 SWC-CFA6-10).

4.2.8 The Newyears Green Bourne, which is not given a WFD classification by the Environment Agency, drains into Harefield No. 2 Lake in the Colne valley. The water body currently passes under Harvil Road via a culvert and has been realigned and culverted west of New Years Green Farm (in CFA7).

4.2.9 Due to the need for in-channel works to facilitate the realignments upstream and downstream of the culvert, mitigation will be incorporated to reduce impacts during construction from a temporary decrease in water quality. Prior to construction starting, a site specific risk assessment will be carried out as required by Section 16 of the draft CoCP. A method statement will be developed as required by Section 4 of the draft CoCP4 and agreed with the Environment Agency. The method statement would draw on the Environment Agency's Works and Maintenance in or near water[9] (PPG5) as described in Section 16 of the draft CoCP. The types of appropriate mitigation to be considered will include the use of physical barriers such as bunds, booms or silt curtains and temporal considerations such as working at times of low flow or in drier conditions. As a result, it is anticipated that the water quality impact will, to the extent practicable, only depart from normal baseline values for short periods, and then towards levels typically achieved during flood events or normal channel maintenance.

4.2.10 The detailed design of the Harvil Road crossing will be agreed with the Environment Agency to ensure that the crossing length and entrance and exit conditions do not

[9] Environment Agency (2007) Works and Maintenance in or near water (PPG5), Available at: http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/pmho1107bnkg-e-e.pdf Accessed: 01/05/2013.

have a significant impact on ecology and morphology. The new crossing will be an improvement upon the existing culvert with respect to surface water quality and therefore the construction activity will have a permanent impact that is considered to be beneficial to water resources. No further mitigation is therefore required.

5 Site specific groundwater assessment

5.1 Summary of assessment

5.1.1 Table 5 summarises the potential impacts to groundwater, WFD status, abstractions, water dependent habitats and surface water/groundwater interactions.

Table 6: Summary of potential impacts to groundwater, abstractions, water dependent habitats and surface water/groundwater interactions.

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Hydrogeology (groundwater)									
Lambeth Group Secondary A aquifer Chalk Principal aquifer	Moderate (Lambeth Group) High (Chalk)	South Ruislip vent shaft	The vent shaft will extend close to the base of the Lambeth Group. Construction may penetrate the Chalk Principal aquifer and dewatering will be needed to construct the base slab within the shaft. The Lambeth Group Secondary A aquifer may be in hydraulic continuity with the underlying Chalk Principal aquifer. The nearest groundwater abstraction is over 1.5km away. (see Section 5.2 of this report)	Negligible impact Neutral effect (Not significant)	The draft CoCP and best practice will protect against potential pollution during construction. Scale of dewatering will be limited.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
Lambeth Group Secondary A aquifer Chalk Principal aquifer	Moderate (Lambeth Group) High (Chalk)	Construction sites	Groundwater contamination from surface infiltration at construction sites will be prevented through the requirements of the draft CoCP and implementation of best practice. There will be negligible impact and neutral effects on groundwater.	Negligible impact Neutral effect (Not significant)	The draft CoCP and best practice will protect against potential pollution during construction.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
Lambeth Group Secondary A aquifer	Moderate	Northolt tunnel west portal	Based on the available information, the tunnel portal would pass through the London Clay Formation and much of the Lambeth Group but will not penetrate below	Minor impact Moderate/ large effect (Significant)	The draft CoCP and best practice will protect against potential pollution during construction.	Negligible impact Neutral effect (Not	None required	Negligible impact Neutral effect	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
			the top of the Chalk.			significant)		(Not significant)	
Lambeth Group Secondary A aquifer	Moderate	Copthall and Brackenbury Cuttings	The cuttings will pass through the London Clay into the Lambeth Group but will not penetrate down to the Chalk. It is likely that this cutting is above the groundwater table and will not interfere with groundwater flow. Risk of groundwater contamination from surface infiltration or spills is increased due to the reduced unsaturated zone over the water table.	Moderate impact if pollution occurred Moderate effect (Significant)	The draft CoCP measures will protect against potential pollution during construction.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Chalk Principal aquifer and SPZ	Very high	Temporary material stockpiles and sustainable placement	Groundwater contamination within the SPZ from surface infiltration though the excavated materials or spills will be minimal since the deposition areas are underlain by London Clay or Lambeth Group strata.	Negligible impact Neutral effect (Not significant)	The draft CoCP and best practice will protect against potential pollution during construction.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
Groundwater abstractions									
Public water supplies protected by SPZ TH174	Very high	Tunnelling activities, vent shaft,cuttings and portal	Construction activities could result in increasing turbidity or introduction of contaminants into groundwater which, if there are fast pathways to abstractions, could result in an	Major impact Very large effect (Significant)	Implementation of the draft CoCP will ensure that materials in contact with groundwater will be selected and method	Major impact Very large effect (Significant)	Until a management strategy is agreed with the Environment Agency in	Major impact Very large effect	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
		construction.	adverse impact to water quality. (see Section 5.2 of this report for further information).		statements developed to control any potential contaminants. Monitoring will take place before, during and after construction until the groundwater quality has stabilised. The monitoring data will be assessed and used to define appropriate mitigation, should it be required.		consultation with Affinity Water, a potentially significant residual effect on the Affinity Water groundwater abstractions remains.	(Significant)	
Private water supplies	High	Tunnelling activities, vent shaft, cuttings and portal construction	Construction activities could result in increasing turbidity or introduction of contaminants into groundwater which, if there are fast pathways to abstractions, could result in an adverse impact to water quality. The private water supplies will be 965m south of the route and will not be directly down-gradient of the construction works in CFA6.	Negligible impact Neutral effect (Not significant)	Monitoring to determine any impact. The monitoring schedule would include monitoring before, during and after construction until the groundwater quality has stabilised. The monitoring data will be assessed and used to define appropriate mitigation, should it be required.	Negligible impact Neutral effect (Not significant)	In the unlikely event that monitoring identifies an adverse effect in water quality, mitigation will comprise the provision of water from a public water supply source unless another alternative will also achieve negligible impact.	Negligible impact Neutral effect (Not significant)	Construction (temporary)

5.2 Detailed assessments

Impacts of shaft and portals

5.2.1 The vent shaft at South Ruislip will extend close to the base of the Lambeth Group and may marginally penetrate the Chalk aquifer. Dewatering is therefore likely to be needed to construct the base slab within the shaft. Abstraction for dewatering purposes from the Lambeth Group or Chalk (should it be penetrated) will only occur to maintain groundwater levels to just below the working levels and the preferred method will be to have dewatering wells sited within the shaft. Site specific investigations leading to a detailed construction methodology will not be available until the detailed design phase and so the assessment is based on professional judgement of the likely conditions that will be encountered. It is concluded that overall there will be a negligible impact on flows and levels in the Chalk aquifer as only the uppermost part of the Chalk and Lambeth Group will require dewatering. There will be a negligible impact on water quality in the Chalk also, with application of the draft CoCP and, therefore, the effect will not be significant.

5.2.2 It is possible some depressurisation of the underlying Chalk aquifer could be required to stabilise the excavation for the tunnel portal base slab to prevent the excavation from breaking up and flooding in an uncontrolled manner during construction. If so this will be undertaken by short term use of temporary, shallow dewatering wells installed within the portal walls. The Chalk aquifer is a high value receptor. Abstraction will only occur to maintain groundwater levels in the Chalk to just below the working levels, so there will be negligible impact on flows and levels in the Chalk aquifer and no impact on water quality in the Chalk and, therefore, not significant effect.

5.2.3 The structure details that have been assumed in assessing the requirements for dewatering are summarised in Table 7. The Chalk groundwater levels and geology data are those reported in the baseline section of this report.

Table 7: Structure dewatering requirements - CFA6.

Structure	Base of structure (m AOD)	Geology	Maximum Chalk groundwater levels (m AOD)	Conclusion
Northolt tunnel west portal (575m by 40m with only around 20-40m length below the water table)	26m AOD	Base of London Clay Formation (35m AOD) Base of Lambeth Group (20m AOD)	30m AOD	Base of structure at base of Lambeth group. Potential dewatering required from 30m AOD to 26m AOD.
South Ruislip vent shaft (40m by 20m)	5m AOD	Base of London Clay Formation (25m AOD) Base of Lambeth Group (8m AOD)	25m AOD	Excavated through base of Lambeth Group into Chalk. Dewatering from around 25m AOD to around 5m AOD required. Base of tunnel at this location is at approximately 11.5m AOD

5.2.4 The resulting estimates of flow rate are summarised in Table 8. These are preliminary estimates using very broad assumptions. In reality, as demonstrated during previous construction dewatering activities, the flow rates required to achieve the desired drawdown may vary significantly from that expected. Assuming dewatering takes place from partially penetrating wells drilled 20m into the Chalk inside the structures and that the Chalk is anisotropic, there will be an estimated six fold reduction in discharge requirement compared to wells drilled external to the structure. The remaining main source of variation in the calculated flow rate is the value of effective transmissivity (T).

Table 8: Estimated flow rates for construction dewatering.

Item	Northolt tunnel west portal	South Ruislip vent shaft
T (m^2/d) (British Geological Survey (BGS) 1997[10])	500	500
D (m)	50	50
k (m/d)	10	10
H (m above tunnel datum)	30	27
h (m above tunnel datum)	20	5
Drawdown (m)	10	20
C (dimensionless)	3,000	3,000
Ro (m)	9.49E+04	1.90E+05
Re (m)	28.5	23
Q external (m^3/d)	1,549	2,787
Q external (l/s)	18	23
Q internal (m^3/d)	258	465
Q Internal (l/s)	3	6

5.2.5 Discharges from dewatering will be recycled back into the Chalk aquifer outside of the shaft and portal or disposed of to sewers or to surface drainage under a suitable permit or consent from the appropriate authority. Dewatering is likely to take place for less than three months. The overall effect of the discharges on water resources will be slight and therefore not significant.

5.2.6 The nearest licensed abstractions from the portal are at least 750m away. The drawdown around the dewatering wells would decrease exponentially with distance from the dewatering well, so it is exceedingly unlikely any drawdown at the licensed abstractions would exceed 2m, indeed additional drawdown is considered likely to be less than 1m. A maximum of 2m interference on drawdown was a threshold considered acceptable on the Crossrail Project[11] since it reflects natural and historic

[10] British Geological Survey (BGS) (1997). The aquifer properties of major aquifers in England and Wales. Technical Report WD/97/34, Environment Agency R&D Publication 8.
[11] Cross London Rail Links Limited, (2005).*Crossrail Environmental Statement, Assessment of Water Impacts Technical Report, Appendix E: Analysis of Impacts on Groundwater*

water level changes. This threshold is considered to be relevant to CFA6 as the hydrogeological strata and conditions are similar to those incurred on the Crossrail Project (see Figure 3, a typical hydrograph for the confined Chalk in the London Basin, and Figure 4, a typical hydrograph for unconfined Chalk in the Colne Valley).

5.2.7 Altering groundwater levels may also have secondary impacts related to settlement of building foundations and buried services and lowering of water levels in areas of archaeological or ecological significance. Historically groundwater levels in this area have varied significantly due to abstractions from the Chalk, and due to normal variations in climate (i.e. drought and wet years). The use of wells sited within the shaft or portal walls and the possible use of recharge wells will reduce the potential water level changes outside the construction area to values much less than have occurred historically (see Figure 3 as representative of groundwater level variations in the confined Chalk). As a result, the effect on water levels will be slight and not significant and the potential secondary effects will not be significant.

5.2.8 It is considered that the construction will not have any significant, permanent effect on groundwater levels and flows in the deep aquifers since there are no large structures to be constructed in the deep aquifer.

Impacts of piling in source protection zone

5.2.9 In this study area there will be piling associated with the Heathrow spur east chord retaining walls. The retaining walls will pass though London Clay and are likely to penetrate into the Lambeth Group and potentially the Chalk aquifer. The regional direction of groundwater flow in the Chalk aquifer is from north-west to south-east (Figure 1). The PWS protected by SPZ TH171 is approximately 655m north-east of the cutting. The piles are likely to only marginally penetrate the saturated Chalk and will not significantly disturb the hydrogeological flow regime. As such, the piling associated with the Heathrow spur east chord retaining walls is unlikely to obstruct principal flow horizons connected to the PWS protected by SPZ TH174.

5.2.10 Notwithstanding this, there is potential for particulates from the bedrock to be dispersed in the Chalk aquifer and, if fast pathways, such as fractures and fissures, exit, there is potential for the water quality to be affected at TH174 and private abstractions within the vicinity of the Proposed Scheme.

6 References

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